Environmental Test Specifications

ECAL electronic QM Crate Thermal and Thermal-Vacuum Test Procedure

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1 Introduction

This document describes the TV (*Thermal-Vacuum*) test procedure for the space qualification of one of the electronics crates of the AMS02 experiment, the crate of the subdetector called ECAL (*Electromagnetic CALorimeter*): the Ecrate.
A general description of the AMS02 experiment can be found in the following site: http://ams.cern.ch/AMS .
The *Ecrate* construction and test is responsibility of the Pisa section of the *Istituto Nazionale di Fisica Nucleare* (INFN), who made the projects and the tests of the full functionality of the Engineering Models. The AMS02 experiment will be equipped with two such crates. The Space Qualification tests of these two crates will be performed on the Qualification Model (QM) according to the procedure described in this note, for what regards the thermal tests. The Flight Models (FM) will follow a similar acceptance test, which will be described in a following note.

The QM/FM tests of the crates will follow the guidelines specified in http://ams.cern.ch/AMS/electronics/SubD/qa/ where most of the reference documents can be found. However, differently from other crates, the Ecrate is not located on the main radiator, therefore the temperature limits have been redefined and agreed upon as specified in the following document: AMS02-SP-CGS-003 titled *AMS-02 E-crate thermal test specification.*

The thermal tests in air will be performed at INFN-Pisa thermal chamber, while the tests in vacuum will be performed at SERMS facility in Terni.

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1.1 Share of responsabilities

It is responsabilities of INFN Pisa of mounting the hardware, including thermal sensors, and perform the tests each time a relevant temperature is reached.
It is responsibility of the hosting facility, which is SERMS in the case of thermal vacuum tests and University of Pisa in case of thermal tests, to operate the chamber, monitoring the sensors and recording the temperature. A final report will be provided with all the recorded data.

2 QM test configuration

2.1 Hardware

All the material going inside the TV chamber has to fulfill specific criteria and must be declared before entering the facility. Appendix A lists all the components, which will enter the chamber. The engineers running the facility must approve this list.

The main component is clearly the Ecrate, described in the next section, while all the other hardware needed to test the Ecrate functionality, described in section 2.1.2, will reside outside the chamber, as the power supplies.

2.1.1 The Crate

The crate has been built at INFN-Pisa machine shop, following the drawings provided by *Carlo Gavazzi Space* (CGS) .
Fig.1 shows a picture of the mechanics; the external white paint is needed for crate reflectivity.
The material used for the construction is the one specified in the drawings of CGS, except that, this being a QM, the aluminum used is *Al7085* with the specification *T6* instead of *T7*. This modification has been agreed with CGS and it does not influence the properties of the crate with respect to the Space Qualification tests.

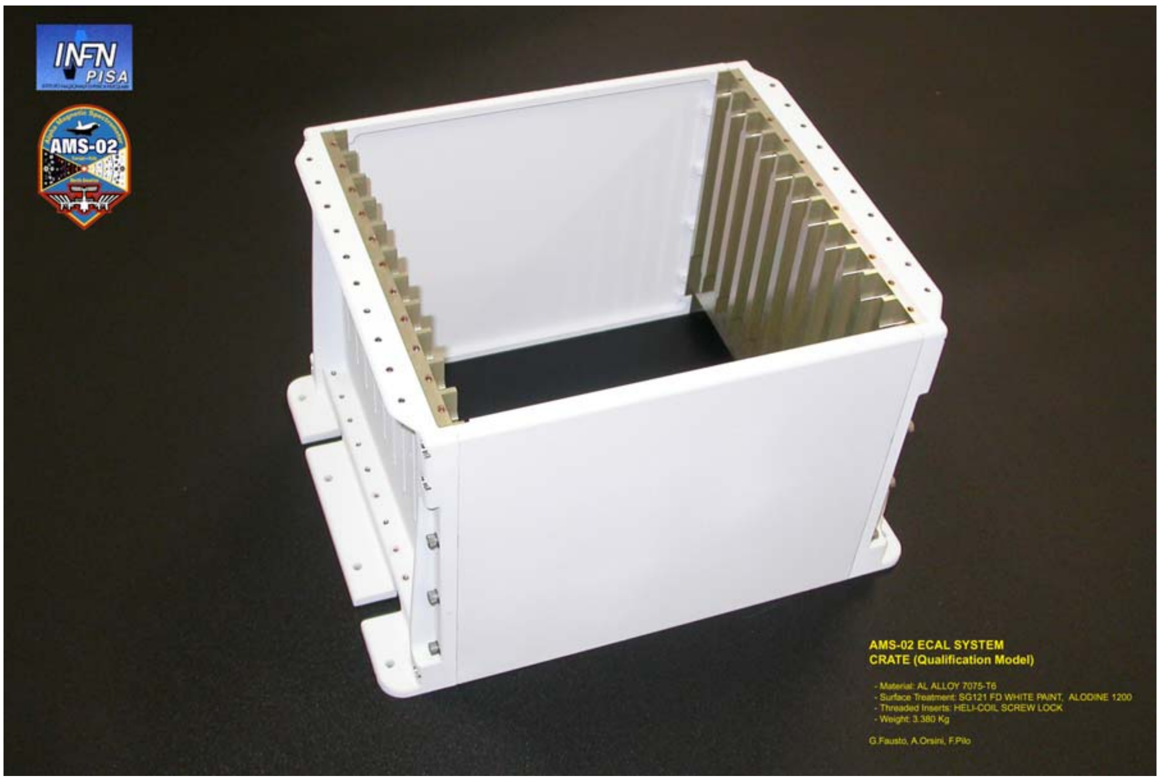

Figure 1 - Mechanics of the Ecrate

The back of the crate is connected to the lower part of the *Unique Structure Support* (LUSS), which is the interface between the Space Station and the whole apparatus. A sketch of the connection between Ecrate and Lower USS is shown in fig.2. The two surfaces are connected by 13 stainless steel (AISI 304) washers, which have been machined in Pisa and which will be used in the tests. The washers insure the thermal and electrical conductivity between the crate and the USS, together with a bonding strap used for electrical connection. Washers + bonding strap will be used in the test to connect Ecrate to TV chamber baseplate.

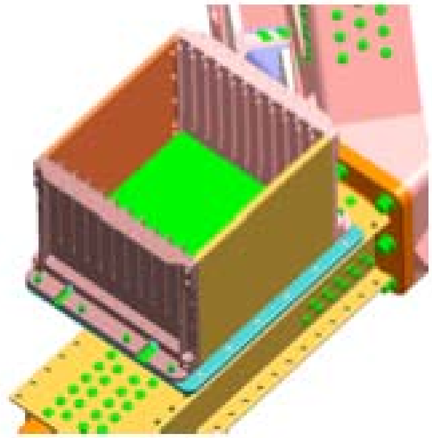

Figure 2 - Ecrate on Lower USS

2.1.2 The boards

The crate is equipper with a total of 11 boards of 4 different kinds, plus a backplane to which the boards are connected. The boards are:

- 6 EDR (Ecal Data Reduction) boards
- 3 EPSFE (Ecal Power Supply for the Front End) boards
- 1 ETRG (Ecal TRiGger) board
- 1 JINF (Data Acquisition) board
- 1 EBP (Ecal BackPlane)

Except for the JINF, which is provided by the AMS electronics team and which is common to most AMS subdetectors, all the other boards have been projected, engineered and tested by INFN Pisa.
For the Space Qualification tests, 1 QM board per type has been built; the rest of the crate, that is 5 EDRs and 2 EPSFEs, will be equipped with the EM version of the boards. The differences between the EM and the QM versions are the components used, commercial in the case of EM and military for QM, the mounting procedure, with a pick-and-place machine for the EM and by hand for the QM, and a factor of 20 in price. Except for this, the two types of boards are identical from the electrical point of view, and this ensures that the thermal gradients inside the crate are the same as for the real one. From the thermal point of view, the commercial components used for the EM have the same operative range as the ones that will be used for the flight and the surface treatment used for the board coating is the same for EM and QM. Therefore this test is well representative of the Ecrate behavior.

2.1.3 Ancillary hardware

The TVT test must be performed while testing full functionality of the Ecrate. For this reason, a set of boards simulating the input/output operations of ECAL detector and the

data acquisition system, are connected to the Ecrate. The connection scheme is sketched in fig.3.
The connection between Ecrate and the simulator boards is done through three thermal-vacuum flanges (DNC200) equipped with TV qualified feedthroughs connectors (*XAVAC* from Positronic Industries). The cables inside the chamber are *flying wires* cables.

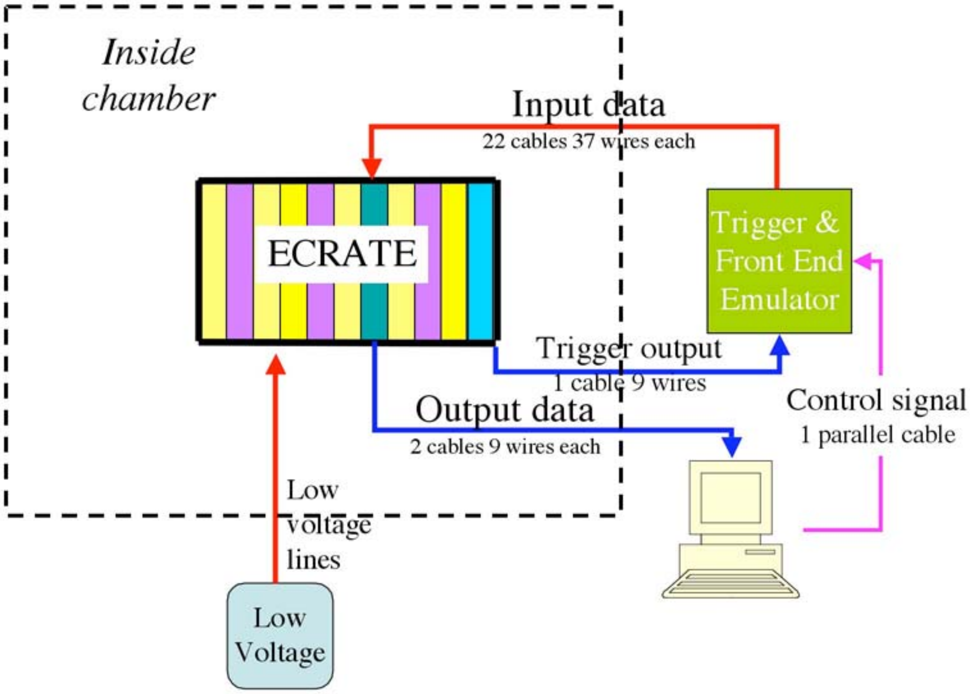

Figure 3 - Sketch of Ecrate SQ tests connection

3 Test profile

The TV test profile is sketched in fig.4 with the following meaning of the symbols:

- T_{AMB} = ambient temperature
- T_{NO-max} = maximum non-operating temperature = +85 °C
- T_{NO-min} = minimum non-operating temperature = -45 °C
- T_{Q-max} = maximum qualification temperature = +55 °C
- T_{Q-min} = minimum qualification temperature = -25 °C

The pressure must be below 10^{-4}hPa to set the first maximum non-operative temperature, and below 10^{-5}hPa before the first switch on operation.

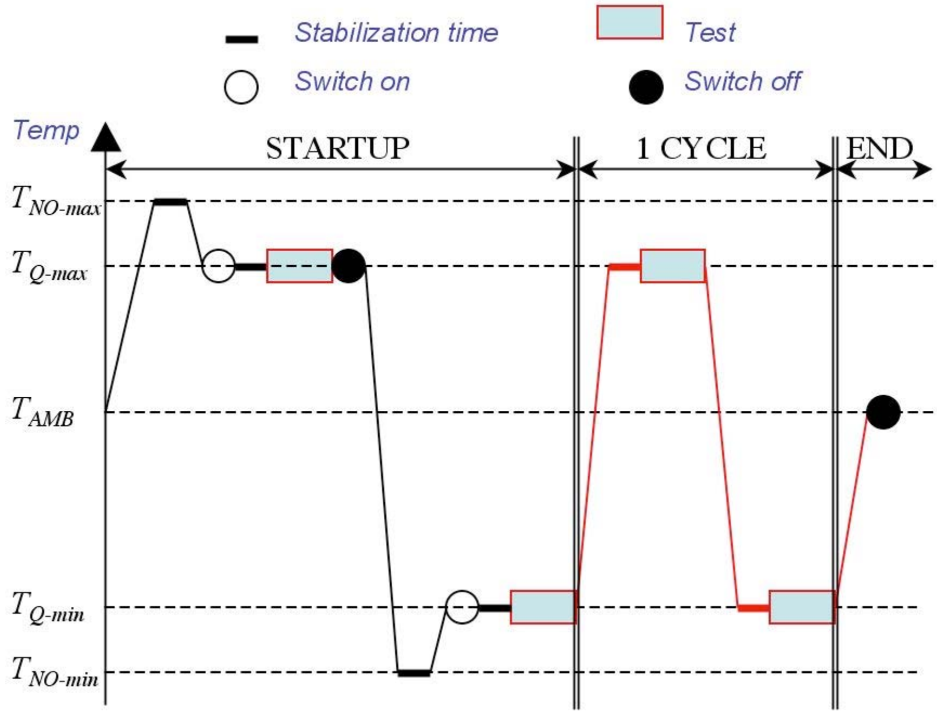

Figure 4 - TV test profile.

The **stabilization time** is defined by the following two conditions, which must be satisfied in sequence:

1. the condition ***$|\Delta T|/\Delta t<1^{O}/hour$*** is reached and maintained for **at least 1 hour**; that is the temperature remains stable and within 1^{O} from the setting for at least **1 hour**;
2. a *dwell time* of **2 hours** is passed.

Following the directions reported in the document *AMS02-SP-CGS-003_issue1.pdf*, the test will be performed in two steps:

1. a test <u>in air</u> with *STARTUP+8 CYCLES+END*
2. a test <u>in vacuum</u> with *STARTUP+1 CYCLE+END*,

where the meaning of *STARTUP*, *CYCLE*, *END* is the one of fig.4.

3.1 TRP location and temperature sensors

All the temperatures described in this document are referred to the *Temperature Reference Point (TRP)*. The location of the TRP is shown in fig. 5; two sensors will be located in this position for redundancy. Other 5 thermal sensors will be located in the center of the 4 lateral faces of the crate and on the face toward the LUSS. The exact location is clearly marked by the presence of 5 rectangular “scratches” in the white paint, which covers the crate. If more sensors are available, provided by SERMS, they will be used to measure with redundancy each temperature.

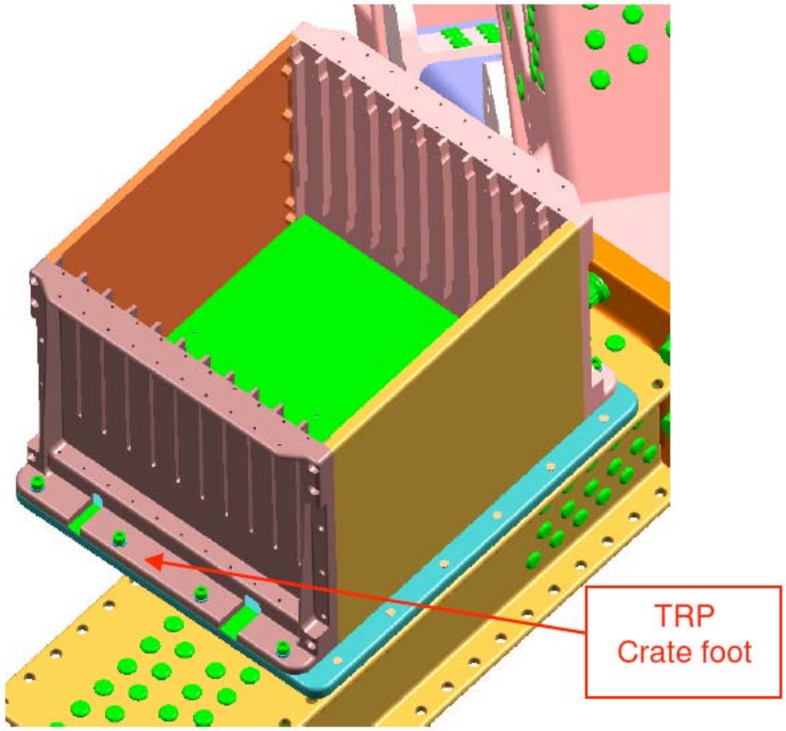

Figure 5 - TRP location; 2 sensors will be glued in this location

Appendix A – List of material to be put in TV chamber

ITEM	Provider	Part number	Mass (kg)
Ecrate	INFN-Pisa	---	7
Baseplate	INFN-Pisa	---	1.4
Wires	Glenair		2
Connectors	Positronic Industries	XAVAC	0.5

Appendix B – Step by step procedure for tests in vacuum

General notes: the tolerance on the TRP levels is 0/+3 degrees, for the HOT and –3/0 degrees for the COLD temperatures.

1. TEST ARTICLE SETUP
    a. PT100 thermal sensors are fixed to the external surface of Ecrate as specified in section 3.3
    b. Ecrate is fixed on the baseplate; the applied torque is 700Ncm
    c. Aluminum baseplate is fixed on the chamber cold plate with the standard torque for M5 screws
    d. Low voltage power supplies and ancillary electronics (front end electronics emulators, EPPCAN, …) are put on a table outside the TV chamber
    e. Cables are pulled between Ecrate and flanges with feedthroughs and between flanges and external electronics
2. PRELIMINARY TEST
    a. The electronics is switched on and a test is performed. In particular:
        i. A set of 10 typical events are sent from the front end emulator boards to the EDR boards; half calorimeter, or 162x4x9=5832 input signals, are emulated (signals are multiplexed in 162 cables)
        ii. These same events are read by the JINF, through the EPPCAN, stored on a PC and compared, bit by bit, with the input events
        iii. The first test is passed if no single difference is found
        iv. The events are read both through the A (Hot) and through the B (Cold) side of the boards, to check full functionality
        v. Another set of events are sent to the ETRG trigger board; given trigger granularity, 102 input signals are sent to ETRG. Signals are then processed by the board and fan out to the common digital part, together with the trigger decision; this output signal is read through JINF and compared to input: no difference must be found and the trigger decision must be the correct one, given the input pattern;
        vi. Finally a power glitch is simulated in the front end boards to which the EPSFE boards must react switching off the solid state fuse
    b. The time it takes to perform these tests is of the order of 40 minutes
    c. Results of the test are stored on the computer together with the temperature readout and the input voltage of the emulator boards as a function of temperature
    d. The current absorption on the 3 power supplies (+3.3V digital, +3.8V and –2.7V) is 2.3A, 2.6A and 2.4A, respectively, at the end of the test
    e. These operations are repeated each time a functionality test is required
    f. A test is passed if no failure in the QM hardware is observed.
3. STARTUP OPERATIONS
    a. The chamber is closed and the vacuum pumping is switched on
    b. As soon as the pressure reaches 10^{-4}hPa, the temperature is set to T_{NO_max}=+85^{O} . The temperature setting is always referred both to the shroud and to the cold-plate controls, which are maintained at the same temperature in particular during crate operation in order to minimize the

heat exchange through the USS interface. During the transient phase, that is while the Ecrate temperature is ramping up or down, the chamber temperature can be set above or below the reference point in order to speed up the process of reaching the setting temperature of the Ecrate.

c. The temperature is reached once the *stabilization condition* (***$|\Delta T|/\Delta t<1^{O}/hour$***) is satisfied and after 1 further hour of stabilization time is passed; this condition must be fulfilled every time in order to define a given temperature as "reached"
d. After a *dwell time* of 2 hours, the chamber temperature is set to the value $T_{Q\text{-}max}$=+55 ^{O}
e. Once the temperature at the TRP is $T_{Q\text{-}max}$=+55 ^{O} and the pressure reaches 10^{-5}hPa , the electronics is switched on
f. After the *stabilization time*, which includes both the *stabilization condition* and the *dwell time*, functionality tests are performed
g. The Ecrate is switched off and the chamber set to $T_{NO\text{-}min}$=-45^{O}
h. After the *stabilization time*, set temperature to $T_{Q\text{-}min}$=-25 ^{O}
i. Once the temperature at the TRP is $T_{Q\text{-}min}$=-25 ^{O} and the pressure reaches 10^{-5}hPa , the electronics is switched on
j. Wait for *the stabilization time* and perform tests

4. CYCLES – to be performed with the device switched on
   a. The temperature is set to $T_{Q\text{-}max}$=+55 ^{O}
   b. After *stabilization*, functionality tests are performed
   c. The temperature is set to $T_{Q\text{-}min}$=-25 ^{O}
   d. After *stabilization*, functionality tests are performed
5. END OPERATIONS
   a. The chamber is set to ambient temperature
   b. Once ambient temperature is reached, the device is switched off
   c. The vacuum chamber is refilled
   d. Once the ambient pressure is reached, the unit is switched on again and tested to verify that the re-pressurization has not caused any damage.

Appendix C – Step by step procedure for tests in air

The tests in air follows exactly the same procedure described in the previous section, except that the vacuum conditions are obviously not required and that the CYCLES section (point 4.) is repeated for N=8 times.

Appendix D – Revision history

10 May 2006	-	Rev 1
15 May 2006	-	Rev 2 – added "step by step procedure"
10 Jun 2006	-	Rev 3 – "step by step procedure" revisited; added tolerances
7 Jul 2006	-	Rev 4 – added the following sentence at the end of point 3b of the

"step by step procedure":

During the transient phase, that is while the Ecrate temperature is ramping up or down, the chamber temperature can be set above or below the reference point in order to speed up the process of reaching the setting temperature of the Ecrate.

This has been added in order to speed up the procedure.